Designation: G183 – 15

Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers[1]

This standard is issued under the fixed designation G183; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes deployment conditions, maintenance requirements, verification procedures and calibration frequencies for use of pyranometers, pyrheliometers and UV radiometers in outdoor testing environments. This practice also discusses the conditions that dictate the level of accuracy required for instruments of different types.

1.2 While both pyranometers and UV radiometers may be employed indoors to measure light radiation sources, the measurement of ultraviolet and light radiation in accelerated weathering enclosures using manufactured light sources generally requires specialized radiometric instruments. Use of radiometric instrumentation to measure laboratory light sources is covered in ISO 9370.

NOTE 1—An ASTM standard that is similar to ISO 9370 is under development and deals with the instrumental determination of irradiance and radiant exposure in weathering tests.

1.3 The characterization of radiometers is outside the scope of the activities required of users of radiometers, as contemplated by this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E772 Terminology of Solar Energy Conversion

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

G24 Practice for Conducting Exposures to Daylight Filtered Through Glass

G90 Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

2.2 *ISO Standards:*[3]

ISO 877 Plastics—Methods of Exposure to Direct Weathering, Indirect Weathering Using Glass-Filtered Daylight and Indirect Weathering by Daylight Using Fresnel Mirrors

ISO 9060 Solar Energy—Specification and Classification of Instruments for Measuring Hemispherical Solar and Direct Solar Radiation

ISO 9370 Plastics—Instrumental Determination of Radiant Exposure in Weathering Tests—General Guidance

ISO TR 9901 Solar Energy—Field Pyranometers—Recommended Practice for Use

2.3 *WMO Reference:*[4]

World Meteorological Organization (WMO), 1983 "Measurement of Radiation," *Guide to Meteorological Instruments and Methods of Observation*, seventh ed., WMO-No. 8, Geneva

3. Terminology

3.1 *Definitions*—The definitions given in Terminologies E772 and G113 are applicable to this practice.

4. Radiometer Selection

4.1 *Criteria for the Selection of Radiometers:*

4.1.1 There are several criteria that need to be considered for selection of the radiometer that will be used:

4.1.1.1 Function specific criteria, such as whether a pyranometer, pyrheliometer or UV radiometer is required,

4.1.1.2 Task specific criteria, such as the accuracy requirements for the selected incident angle and temperature ranges, and maximum response time,

4.1.1.3 Operational criteria, such as dimensions, weight, stability and maintenance, and

4.1.1.4 Economic criteria, such as when networks have to be equipped, or whether the instrument is being acquired for internal reference purposes, or for research purposes, etc.

[1] This practice is under the jurisdiction of ASTM Committee G03 on Weathering and Durability and is the direct responsibility of Subcommittee G03.09 on Radiometry.

Current edition approved Feb. 1, 2015. Published February 2015. Originally approved in 2005. Last previous edition approved in 2010 as G183 – 05(2010). DOI: 10.1520/G0183-15.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[4] Available from World Meterological Organization, 7 bis, avenue de la Paix, CP. 2300, CH-1211 Geneva 2, Switzerland, http://www.wmo.int.

4.2 *Selection Related to Radiometer Type:*

4.2.1 Pyranometers, which measure global solar irradiance in the 300 to 2500 nm wavelength region, are required to assess the hemispherical solar irradiance on surfaces of test specimens mounted on weathering test racks that are used by the outdoor weathering exposure community. Typically, pyranometers are required to measure the exposure levels specified in the applicable ASTM and/or ISO outdoor weathering standards such as those described in Practices G7, G24, G90, and ISO 877.

4.2.2 Pyrheliometers, which measure direct (or, beam) solar irradiance in the 300 to 2500 nm wavelength region, are required to assess the solar irradiance reflected onto the target board by the mirrors of Fresnel Reflecting Concentrators used in outdoor accelerated tests specified by ASTM and ISO Standards described in Practice G90 and ISO 877.

4.2.3 Ultraviolet radiometers are either broad band or narrow band instruments covering defined wavelength regions of the solar ultraviolet spectrum.

4.2.3.1 Broad-band UV radiometers usually are designed to measure either UV-A, UV-B or some component of both UV-A and UV-B radiation.

NOTE 2—Certain UV radiometers that are designated as total ultraviolet radiometers are advertised to measure over the total wavelength range from the so called UV cutoff at approximately 300 nm to 385 or 400 nm, but in fact measure mostly UV-A radiation by virtue of their very low responsivity to wavelengths below 315 nm.

4.2.3.2 Narrow-band UV radiometers are essentially constructed using interference filters that isolate narrow bands of radiation having FWHM values of 20 nm, or less; their center wavelengths (CW) may reside anywhere in the UV spectrum from 280 to 400 nm wavelength—depending on the application for which they are intended.

NOTE 3—While the World Meteorological Organization (WMO) and the International Standards Organization (ISO) have established requirements for Secondary Standard and High, Good, and Moderate Quality pyranometers and pyrheliometers, specifications and required operational characteristics of different classes of ultraviolet radiometers have not been addressed by either organization.

NOTE 4—High Quality instruments are not necessary for all applications.

4.3 *Selection Related to Measuring Specifications:*

4.3.1 As a first step, all possible ranges of measuring parameters such as temperature, irradiance levels, angles of incidence, tilt angles, and station latitude, must be compiled.

4.3.2 Next, documentation must be compiled of available information about the technical characteristics, and the technical and physical specifications of the relevant radiometers given by:

4.3.2.1 The WMO and ISO classification of pyranometers given in the WMO Guide, and in ISO 9060 and ISO 9370 (which together define the specifications to be met by different categories of pyranometers and pyrheliometers),

4.3.2.2 The data specification sheets obtained from the manufacturer, and

4.3.2.3 Preferably, data on the technical characteristics and performance obtained from independent sources such as independent testing laboratories, research institutes and government laboratories.

4.3.3 If the accuracy of the highest category of instrument is insufficient for the application contemplated, the following recommendations are given:

4.3.3.1 Hemispherical solar radiation may be measured by the simultaneous deployment of a pyrheliometer and a continuously shaded secondary standard pyranometer to achieve accuracies that are greater than can be achieved by a secondary standard pyranometer alone,

4.3.3.2 Direct (beam) solar radiation may be measured using an absolute cavity pyrheliometer employing electrical substitution of thermally absorbed radiation to achieve accuracies that are greater than can be achieved by a First-class pyrheliometer, and

4.3.3.3 Specific ultraviolet wavelength bands may be determined by integration of the selected wavelength bands using a scanning spectroradiometer possessing good slit function and narrow band pass characteristics to achieve accuracies that are greater than the most accurate narrow or broad band ultraviolet radiometers currently commercially available.

5. Practice for Use—General

5.1 *Installation of Radiometers:*

5.1.1 When performing measurements in support of testing, the test object and the field radiometer shall be equally exposed with respect to field of view, ground radiation and any stray light that may be present. This means that the test surface and the radiometer shall receive the same irradiance.

5.1.2 When used to determine the irradiance accumulated on solar concentrating devices such as the Fresnel reflecting concentrators used in Practice G90, and other types of solar concentrators, it is essential that the collection system of the solar concentrators, such as the flat mirrors used in Practice G90, do not receive direct irradiance that is unavailable to the optical system that connotes the pyrheliometer required.

5.1.3 The need for easy access to the radiometer for maintenance operations shall be considered in selecting the installation site, mount, etc.

5.2 *Electrical Installation:*

5.2.1 The electrical cable employed shall be secured firmly to the mounting stand to minimize the possibility of breakage or intermittent disconnection in severe weather.

5.2.2 Wherever possible, the electrical cable shall be protected and buried underground—particularly when recording devices, controllers, or converters are located at a distance. Use of shielded cable is highly recommended. The cable, recorder and other electronic devices, shall be connected by a very low resistance conductor to a common ground.

5.2.3 Contact the manufacturer of the radiometer being installed to establish the maximum allowable cable length permissible for the instrument's impedance so as to preclude significant signal loss (see 5.4.5.2 for additional requirements).

5.2.4 When hard wiring electrical connections, all exposed junctions shall be weatherproofed and protected from physical damage.

5.2.5 Establish and identify the polarity of all relevant connections prior to connecting to the recording device, converters, or controllers. Make all connections in accordance with the manufacturer's instructions.

5.3 *Required Maintenance Activities:*

5.3.1 *Inspection:*

5.3.1.1 Whenever possible, inspect radiometers employed in continuous operation at least once each day. Inspection and maintenance activities of specific attributes described in the following sections should be carried out daily, monthly and yearly as indicated.

NOTE 5—It should be noted that the quality of data obtained using total solar and solar ultraviolet radiometers depends strongly on the amount of personal attention given during the observation program.

5.3.2 *Daily Routine Inspection and Maintenance:*

5.3.2.1 The exterior glass domes and/or diffusers or windows, shall be inspected daily and cleaned at least once each week or more often whenever dust or other deposits are visible. Cleaning shall occur by spraying with deionized water and wiping dry with non-abrasive and lint-free cloth or tissue. It is recommended that this inspection and possible cleaning be performed early each day.

5.3.2.2 If frozen snow, glazed frost, hoar frost or rime is present, remove the deposit very gently, initially with the sparing use of a de-icing fluid or a warm lint-free cloth, appropriate for the type of glass dome, window, or diffuser, after which the glass dome, window, or diffuser shall be wiped clean and dry.

5.3.2.3 After heavy dew, rain, sleet, snow or frost buildup, check to determine if condensation is present inside the dome, or on the receptor or diffuser surface. If condensation is discovered inside the dome, on the receptor or diffuser surface of domed radiometers, the instrument's manufacturer shall be contacted to determine a course of action.

NOTE 6—The user may attempt to "dry out" the radiometer by elevating its temperature, either in natural sunlight or in the laboratory, to 50°C. If the condensation is eliminated, the radiometer's calibration constant shall be checked prior to being returned to service.

5.3.2.4 When hard-to-remove deposits of air pollution or local contamination is observed on a radiometer's exterior window, first apply deionized or distilled water on the surface. If the use of a detergent solution is indicated, a prepare a 2 % solution of a mild dish washing detergent and gently apply to the surface. Use a soft, lint-free muslin cloth to gently rub the surface if required. In either case, thoroughly rinse the surface with deionized or distilled water, after which it the window shall be wiped clean and dry. Water spots should not be evident on the surface. However, care should be exercised to avoid scratching the surface.

NOTE 7—The user may use optics cleaning compressed air to blow away all remaining water droplets from the surface after cleaning. Use small, controlled puffs of air, being careful not to discharge any propellant that may leave a residue on the window. Check for any streaking or lint left by the cleaning materials and repeat if necessary.

5.3.2.5 When used, check the operational state of the ventilator or air blower at least weekly and note any unusual noise for subsequent attention. Further, check the condition of ventillation unit filters and clean or replace as necessary.

5.3.2.6 Perform a cursory check of the output data on at least a weekly basis to determine if data being recorded are plausible in relation to the conditions being experienced.

5.3.3 *Monthly Routine Inspection and Maintenance:*

5.3.3.1 Examine the color-indicating desiccant for all instruments where the silica gel container is accessible. If moisture is indicated, replace the desiccant.

NOTE 8—If desiccant is consumed rapidly, the cause might be a defective seal of the instrument's window, a defective electrical connection into the instrument case, or a defective O-ring associated with the desiccant chamber.

5.3.3.2 Attention should be paid to the transmission and amplification of signals. Perform both visual and electrical checks of the cable and amplifier (when used). These inspections shall also be performed when any component of a measuring system has been replaced, or after any anomalies have been detected in the data.

5.3.4 *Quarterly Inspection and Maintenance:*

5.3.4.1 In those radiometers where the desiccant is not visible, remove the desiccant cover and inspect the desiccant for dryness. If moisture is indicated, replace the desiccant. Care should be exercised to ensure that the desiccant container's cover is closed completely (manufacturer's instructions should be followed with respect to ensuring the tightness of the cover, or cap).

5.3.4.2 Verify that the responsivities of all radiometers have not changed to the extent that they are out of tolerance. This can be done by comparison to another radiometer that has the same spectral response function[5] or by determination that the ratio of, for example, UV-B to UV-A irradiance has remained essentially the same (if both measurements are being performed), or, as will usually be the case, if the ratio of total solar UV irradiance to total solar irradiance has remained essentially the same for clear day solar noon conditions.

5.3.5 *Semi-annual Inspection and Maintenance:*

5.3.5.1 Use an inclinometer[6] to determine the inclination of all radiometers mounted at tilts from the horizontal. Inspect the inclination angles of all pyranometers and UV-radiometers including the spirit level of all horizontally mounted radiometers.

5.3.6 *Yearly Inspection and Maintenance:*

5.3.6.1 When calibration schedules do not require annual re calibration, special attention should be paid to the possibility of drift in the sensitivity (that is, the calibration factor) of the radiometer. This shall be accomplished by use of either a field re calibrator (in the case of certain UV-A and UV-B radiometers) or a field reference radiometer maintained by the testing/measuring facility for that purpose.

5.3.6.2 Inspect all radiometers for general deterioration of the instrument—including domes and windows (to detect chips, cracks, or the development of any optical disparity), the receiver coating (to detect discoloration, loss of material, checking, or cracks), and seals (to detect severe discoloration, cracking, degradation, etc.).

5.3.6.3 When either drift in sensitivity greater than the tolerance established by the testing/measuring facility, or greater than permitted by the applicable standards or specifications, or when any degradation of instrument components is noted, the manufacturer should be contacted to

[5] This is most easily achieved by comparing with a UV radiometer of the same model.

[6] A protractor scale equipped with a rotatable spirit level.